Chapter

Organic Grain Legumes in India: Potential Production Strategies, Perspective, and Relevance

Amanpreet Singh and Harmandeep Singh Chahal

Abstract

Organic agriculture comes from the conscious efforts of people who are inspired to create the best possible relationship between the earth and humans. Since its inception, the sphere surrounding organic farming has become much more complex. The introduction of legumes into crop rotation is not a new concept, legumes such as peas and chickpeas were introduced into cereal-related crop rotation during the Harappan period of the chalcolithic period at the end of 3000 BC. The grain yield after legumes in the grain system is 30 to 35% higher than the grain in the crop chain. Legumes play a unique role in organic farming systems because of their deep root system, ability to fix nitrogen, and the ability to rotate and rotate systems.

Keywords: organic farming, legumes, nutrient, pest, constraints

1. Introduction

Organic agriculture comes from the conscious efforts of people who are inspired to create the best possible relationship between the earth and humans. Since its inception, the sphere surrounding organic farming has become much more complex. A major challenge of today's agriculture scenario is food contamination of unhealthy chemicals related to fertilizers, herbicides, and pesticides. Over the past two decades, the global community has also been sensitive to preserve the environment and food quality. Enthusiastic promoters of organic farming believe that it can meet these two requirements and become a comprehensive means of rural development. After nearly a century of development, organic farming has gained public acceptance and shows great commercial, social, and environmental promise. Although there has been a constant mindset from the very first days to the present day, the modern organic movement is completely different from its original form and based on environmental sustainability, as well as the founder's interest in healthy soil, healthy food, and healthy people. Organic farming is the best way to improve soil quality and the health of organisms. Today, the world recognizes the importance of quality food products that are not contaminated by synthetic materials, namely chemical fertilizers, pesticides and pesticides in agricultural production, and hormones and chemicals used in the livestock industry. Synthetic fertilizers and pesticides are not necessary to maintain a sufficient supply of nutritious food to feed the developing world population and worse, can lead to environmental degradation in general, and soil quality in particular. So manipulation of organic farms with the utilization of natural resources is necessary for the form of sustainable management based on the agronomic alteration of present agriculture scenario. Legumes have good potential to diversify farming systems on organic farms. Introducing legumes into organic production systems add to improving soil fertility by fixing nitrogen and releasing phosphorus nutrients. Therefore, in legume rotation, the subsequent grain yield and the crude protein concentration in the seed may increase due to excess nitrogen provided by the previous legume. Legumes help in increasing organic matter and microbial biomass, soil activity, improve soil structure and water holding capacity while helping to reduce water erosion. Crop rotation plays an important role in organic farming, and rotations include legumes that allow for future production in the same land. The versatility of legumes allows them to be used in biological systems in different ways: crop rotation, intercropping, level cultivation, and cover crops. To reach the full yield potential of crops in organic production systems at all times, legumes must account for at least 30% of the total crop area [1]. The introduction of legumes into crop rotation is not a new concept, legumes such as peas and chickpeas were introduced into cereal-related crop rotation during the Harappan period of the chalcolithic period at the end of 3000 BC. The grain yield after legumes in the grain system is 30–35% higher than the grain in the crop chain. Legumes play a unique role in organic farming systems because of their deep root system, ability to fix nitrogen, and the ability to rotate and rotate systems. The choice of the utilization of grain legumes in organic farming increases day by day due to the increasing consumption of organic productions due to improvement in organic markets.

2. Status of grain legumes under organic farming vs. conventional farming

Recognizing the importance of clean food for people, the demand for organic products, especially in developed countries, is increasing day by day. Worldwide, 1.8 million farm households in 162 countries practice organic farming on 37 million hectares of land. The largest areas of organically managed agricultural land are Oceania (12.1 million hectares or 33% of the world's organic agricultural land), Europe (10.6 million hectares or 29% organic agricultural land of the world), and Latin America (6.8 million ha or 23%). India now ranks 10th among the top 10 countries in the world for organic certified farmlands. The certified area covers 15% of the cultivated area with 0.72 million ha and the remaining 85% (3.99 million ha) is left in the forest and wilderness to collect small forest products. The total area under organic certification is 4.72 million ha (2013–2014). In terms of production, India has produced about 1.24 million tons of certified organic products including sugarcane, cotton, oilseeds, basmati rice, legumes, spices, tea, fruits, dried fruits, vegetables, coffee, and value-added products and organic products is not limited to food items but it also includes an organic cotton and other daily items, etc. Of all the states, Madhya Pradesh occupies the largest area of organic produce certification, followed by Himachal Pradesh and Rajasthan [2].

In India, the main grain legumes are based on pulses and oilseeds and the main crops are lentils, grams, peanuts, soybeans, and pigeons (**Table 1**), but the organic production of organic grain legumes is only 1.44 million tons [3]. Organic production of grain legumes is low as compared to conventionally produced legumes but their production was improved day by day by the implementation of new research modules developed by agricultural institutes. Organic grain legumes not in terms of consumption are better utilized but it is developed as a backbone of agriculture markets in terms of export to other countries at higher rates. Soybeans (70%)

Crop	Total area (MH)	Total production (MT)
Lentil	1.55	1.61
Gram	10.56	11.23
Groundnut	4.91	9.18
Soybean	10.47	10.98
Pigeonpea	4.43	4.25

**Agricultural Statistics at a Glance 2018 (Government of India).*

Table 1.
Major grain legumes in India.

topped export products, followed by cereals and millet different from basmati (6%), processed food products (5%), basmati rice (4%), sugar (3%), tea (2%), legumes (1%), nuts (1%), spices (1%) and others (www.opeda.org). The Indian Government launched the National Organic Production Program (NPOP) in 2001. States like Uttarakhand, Karnataka, Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Tamil Nadu, Kerala, Nagaland, Mizoram, and Sikkim have encouraged organic agriculture based on cereals, pulses, oilseeds, and horticultural crops.

3. Crop production techniques in organic grain legumes

3.1 Choose the right variety

The legume improvement program began in 1917 with selections from different parts of the country, especially pigeonpea. Today, a large number of improved varieties have been published to improve yield, resistance to pests and pests, short duration, synchronized maturation, a small size, etc., adapting to conditions of different farmland. Generally, genetically improved varieties are not allowed in organic farms so selection or crop improvement in legume varieties should be based on adaptability to the agro-climatic conditions of locations and resistant to abiotic and biotic stress should be developed. The old desi varieties have low productivity, but their potential towards stress conditions was so good and acceptable.

3.2 Sowing time

Planting time is the most important non-monetary contribution that significantly affects crop growth and productivity [4]. A delay in planting limits the vegetative growth; a number of fruit-bearing branches or stems branches and leads to forced maturity and poor productivity. At the same time, the incidence of pests, especially the European stem borer (*Helicoverpa armigera*) on green beans [5]. Growing lentils from November 15th to 20th in Tripura gives maximum grain yield compared to early or late planting [6]. Agronomic alteration based on sowing time or date of sowing is a good manipulation on organic farms without the utilization of any unnecessary source.

3.3 Water management

In India's, there are two main water management issues: (i) water surplus and subsequent flooding problem during the Kharif season and (ii) water shortage during the Rabi season (November to April). Legumes need adequate drainage because they are prone to water-logging [7]. Legumes are mainly grown as rainfed crops in the semi-arid and arid areas. However, legumes grown during the summer months require significant irrigation, especially during the critical period, when soil moisture becomes a limiting factor. The vegetative, flowering and fruiting stages are very important in pulse physiology so adequate management of irrigation scheduling at these stages is important. In water deficit areas, alternate-furrow irrigation and water conservation techniques is a good approach.

3.4 Tillage

Arable land is necessary to treat the soil with agricultural tools and tools to obtain ideal conditions for seed germination, seed establishment, and plant growth. The main objective of tillage is to create good soil and soil conditions for crop establishment and initial development of roots and shoots. The Kharif legume requires tillage to open the soil through a rotating plow and two cross wrinkles followed by a plank. In Rabi legumes, soil plows after Kharif and if necessary, irrigation should be given before planting to ensure adequate moisture. Recycling of summer mung bean residues (*Vigna radiata*) through rotary tillers and cropping systems increases system productivity, profitability, and soil health [8]. Crop residue incorporation in organic fields with the help of tillage techniques is also a good approach for management of fertilizer needs of crops and improves organic matter content of the soil.

3.5 Geometric planting

The optimal space needed depends on the type of crop, the variety, the planting season, and the cropping system. Most short-lived legumes need a small space, while long-term varieties work well with a larger space. Appropriate planting densities in fields and vegetables lead to better use of solar radiation to turn into higher yields. Planting in the first week of June will have the highest percentage of pods or seeds in grain legumes. Tighter and wider gap performance in different varieties and sowing after this date have reduced grain yield [9]. Growing green peas at a distance of 20 cm × 10 cm is more sufficient to get good yield benefits [10]. In general, Kharif cultivation requires greater spacing and a smaller plant population than summer crops due to relatively warm temperatures, long vegetative growth, and abundant branching.

3.6 Seed priming

Seed soaking in water for 10–12 hours and shade drying enhances germination percentage and early emergence under rainfed cropping. The seed priming in organic farming refers to soaking the seed in organic liquids. In the broadcast method, the established seed was low so seed soaking and priming a good tool to achieve the desired yield. Gupta and Bhowmick [11] stated that the sowing of pre-sprouted seeds significantly increased the pod number per plant, seed per pod, and test weight in Lathyrus.

3.7 Nutrient management strategies in organic legume production

No doubt, legumes are a very important food crop to improve human nutrition having high protein and nutrient content. Biological response of legumes to plant growth-promoting bacteria (PGPB) or bio-fertilizers is an effective and environmentally safe approach to reduce dependence on chemical and inorganic fertilizers causing soil pollution. Phosphorous (P) deficiency in soil is often a major factor in poor legume productivity. The productivity of legumes can be significantly increased by applying P based on soil analysis information. P applied to legumes can produce residual effects up to a limit of 20 to 35 kg P_2O_5 ha^{-1}. Seeding or seed application with P-soluble organisms such as PSB and PSF increases P-use-efficiency. The level of response to applied P can be further improved by timely management, planting, and source used, maintain optimal plant populations, maintain adequate moisture, low pest incidence, and weed control effectively [12]. Treating seed with bio-fertilizer (rhizobia) can increase legume productivity by 10–12%. The combined use of microbial cultures, such as rhizobium and P based biofertilizer (VAM), leads to higher seed yields of the crop than rhizobia cultures alone. Although good results have been achieved at the research stations, the adaptability of integrated nutrient management (INM) technologies to farmers at the farm level is during early phases of organic farm formations. More attention should be paid to the development and identification of suitable bio-fertilizer strains for major legume systems for different agronomic conditions through integrated methods developed by agronomists, biologists, and microbiologists. The availability of biofertilizer is easy and at cheap rates to the organic farms so better adaptability by farmers to this technology of nutrient management [13]. Several studies have shown that spraying panchgavya at 3% helps improve plant growth because it contains micro and macronutrients and favorable growth hormones. The enzyme in panchagavya promotes rapid cell division and multiplication, helping to improve plant growth patterns. Kumaravelu and Kadambian [14] reported that spraying panchgavya (3%) 10 days after planting (DAS) significantly increased the growth of Greengram plants, resulting in higher grain yield. Several other liquid organic manures such as jeevamrit are also a good option for nutrient management in organic legumes.

3.8 Organic pest and disease management in organic grain legumes

The main issue is the organic management of insects and pests in organic farming. Natural predators should be encouraged and protected (for example, farming trees on farms that attract pests and insects, etc.). Products collected from local farms, animals, plants, and microorganisms and prepared on the farm can control pests. Extracts from neem seed core (NSKE), cow urine sprays are beneficial for pest control. Products authorized to control pests are neem oil and other neem preparations such as NSKE, color traps, mechanical traps, pheromone traps, herbal remedies, mild soaps, and clay, etc. A mixture of 3–5 L cow urine and an equal amount of manure (3–5 kg) stored for 4 days and filtered it. Add 200 g of lime and obtain up to 80 L and spray along with cow's milk in legumes control mosaic, a type of viral diseases (also called yellow mosaic virus) in which whey acts as a good barrier for reducing transmission of YMV [2]. Legumes are susceptible to pests and diseases. Productive losses due to the absence of plant protection measures vary from 46 to 96% depending on the crop and variety in legumes and further in case of organic legumes it can be increased up to complete crop failure. Integrated pest management (IPM) in legumes includes the use of resistant varieties, crop rotation with non-host plants, etc. also a good approach in the management of diseases and pests on organic farms. In Arunachal Pradesh, straw humus reduced the incidence of Ascorobta on peas as mulch application by regulating temperature and humidity [15]. Caterpillars are the most devastating legume insect due to favorable weather conditions. So regular inspections of farms on a daily or weekly basis were implemented.

3.9 Impact on soil dynamics: physical, chemical, and biological properties

Intensive agricultural practices lead to degradation of soil aggregates, resulting in soil erosion and loss of soil organic matter (SOM) [16]. Legume crops increase SOM, help aggregate soil particles, and crop residues obtained from legumes are considered a good technique for sustainable soil management because it prevents soil erosion, improve water holding capacity and help restore soil biodiversity.

3.9.1 Physical properties

Legumes in the form of mulch or crop residue act as a soil conditioner, as they positively affect soil microbial populations by providing them with a substrate, increasing the degradation of the debris or residues of plant and the addition of organic matter to the soil in large quantities [17] lead to the prevention of soil/wind erosion, improved soil agglomeration and water holding capacity, etc. Therefore, legumes play a very important role in soil restoration and provide a favorable strategy to improve soil health for sustainable agriculture.

3.9.2 Chemical properties

Legume cultivation has a tremendously positive effect on soil chemistry. In particular, the pH of the soil decreased due to the production of organic acids and CO_2 from legumes degradation in alkaline soils [18]. Therefore, legumes act as a buffer for the soil by maintaining its pH. The addition of legume crops to intensive farming systems significantly reduces soil and water pollution. Crop residue incorporation based on legumes improves the availability of macro or micronutrients also.

3.9.3 Biological properties

The practice of intercropping with legumes helps in the development of different types of roots capability of fixing nitrogen and is therefore responsible for changing the complete distribution of the roots, as well as the root architecture, as well as modifying the secretion process in the rhizosphere. Therefore, it can strongly influence the microbial community as well as its interactions with the crop, thus promoting various benefits. Intercropping of cereals and legumes also promotes replenishment and facilitation in agricultural systems [19]. Legumes are also thought to promote the invasion of *arbuscular mycorrhizae* (AD) in low-input input agricultural systems, as legumes actively participate in trilateral symbiotic relationships between different microbial species [20]. There is a gradual improvement in the diversity and abundance of mycorrhizae in legume cultivation.

4. Biological N-fixation by grain legumes

The grain legumes can fix nitrogen biologically with the help of a symbiotic and mutual partnership with rhizobia bacteria. N-fixation of grain legumes is about 1.0 kg ha day^{-1} within a cropping season. Most of the excess fixed nitrogen is completely utilized by the second relay crop or it will help in decrease nitrogen demand of the next crop. Legumes can fix up to 100 kg nitrogen per hectare depending upon crop type, management, and agro-climatic conditions. Mostly all grain legumes fix nitrogen such as gram (26–63 kg ha^{-1}), pigeon pea (68–200 kg ha^{-1}), mungbean (50–55 kg ha^{-1}), and lentil (35–100 kg ha^{-1}) [21].

Crop	Wheat	Rice	Lentil
N %	0.39	0.48	1.74
P%	0.13	0.16	0.16
K%	1.10	1.03	1.74

Table 2.
Nutrient concentration and C:N ratio of rice, wheat, and lentil straw.

5. The remaining impact of legumes on agricultural systems

Crop rotation can improve biomass production and can sequester carbon (C) and nitrogen (N) in the soil, mainly crop rotation with non-legumes, and C and N can be improved with effects consecutively, for example, the increase in maize yield in legume rotation is a 50% successful plantation when grown with sesame [22]. Intercropping with legumes may increase soil N, and this total N may not be available during the current growing season, improving soil fertility for successful cultivation [23]. Lopez and Mundt [24] observed that velvet bean (*Mucuna pruriens*), and sun-hemp (*Crotalaria juncea*) often resulted in maize yields of 4 to 7 mg/ha even without applying additional nitrogen fertilizer in the next harvest. Yusuf et al. [25] reported that to maximize the contribution of legumes N to the next crop, it is essential to maximize the total amount of N in legumes, the amount of N mineralized legumes, and the effectiveness of legumes. The use of this mineral N and the amount of N derived from immobilization Nair et al. [26] observed that legumes, especially soybeans, cowpea, peas, and peanuts intercropping with maize have the remaining or residual effect on the yield of a subsequent wheat crop. Intercropping of sorghum with peanuts, cowpea, and green gram reduces the N demand of wheat fertilizer to 61, 83, and 38 kg/ha for a target yield of 4.0 tons/ha. Grain legume crops have deep root systems in the soil so they can recycle crop nutrients that are deep in the soil profile and also have the ability to hold different nutrients in high amounts in their biological content (**Table 2**).

6. Grain legumes also act as intercropping and green manure in organic farming

Intercropping is practiced to meet different ecological goals, such as promoting interaction between species, activating natural regulatory mechanisms, increasing biodiversity, and reducing farmers' risk against climate aberration [27]. The main objective of the legume intercropping system is to produce more yields from the same field and improve the efficiency of natural resources compared to monoculture [28]. Mixing a legume with a non-legume species may have a performance advantage over monoculture. Legumes improve soil function through the symbiosis of the legume-rhizobia [29]. The main objective of the legume intercropping system is to produce more yields from the same field and improve the efficiency of natural resources compared to monoculture [28]. Mixing a legume with a non-legume species may have a performance advantage over monoculture. Under favorable environmental conditions, legumes add N to the system, obviously leading to high yields of major crops [30]. Barbosae et al. [31] reported that 25% of the fixed N per cowpea component was transferred to corn. An important goal of intercropping is to ensure higher yields per unit area than monoculture [32]. Compost refers to the inclusion of crumbling fresh plant remnants in soils undergoing biodegradation using the soil microbiota and contributing to soil organic matter. Legumes are an effective green manure crop because the decomposed plant matter after harvest can improve soil water retention and water retention, reduce soil erosion and increase SOM, and thus improve soil properties. Different benefits can be used to enhance crop yields [33]. Green manure can be classified into two categories according to their manure position, *i.e.* local green manure, and green manure (Onsite and offsite). In the case of local green manure, legumes are planted and added to the soil on the same site, while in the case of green manure; legumes' waste is collected at the nearest location and added to the soil first, plant the next harvest. Besides, legumes have a wide range of properties such as biological nitrogen fixation, short time, against abiotic and biological stress, environmental flexibility, fast, simple off-farm production, etc. Better monitoring of agricultural sustainability is achieved by legumes addition in organic farming [34].

7. Microbiological changes under organic legumes

Legumes are one of the important components to increase soil microbial biomass (SMB) in the soil [35]. Legumes play an important role in small and medium-sized businesses and important energy processes, such as the nutrient cycle and disruption of SOMs, thus improving crop yields and soil sustainability [36]. The instability of small and medium-sized enterprises implementing several important agronomic processes in the soil can drastically change agricultural productivity and soil sustainability [37]. The relationship between biota and legume in the soil and their significance for the various soil functions has a positive impact on soil sustainability [38]. SMB was increased by rotation of legumes with significant improvements in the structure of soil microbial communities and soil health [39]. Some microorganisms that interact physically with legumes in the rhizosphere can also actively improve crop yields by increasing plant growth and growth [40]. The SMB is similar to the eye of a needle than any SOM must overcome [41] and is therefore widely used as a biological indicator in soil sustainability [38]. SOM is an instant sink for nutrients, organisms, and carbon. SMB also increases the nutrient supply in cultures in symbiotic associations. It contributes to the physical structure of the soil, chemical processes, and pesticide degradation and prevents soil pathogens [42]. SMB and microbiological dynamics are related indicators of changes in soil sustainability due to changes in soil properties. SMBs are mainly found in surface layers and vary according to soil configuration. SMB is a living element of the soil. Tilak [43] stated higher counts of actinomycetes, bacteria, *Azotobacter, fungi,* and PSB due to growing of mungbean in fallow after rice (**Table 3**). These increments in the microbial population in turn affect mineralization and immobilization of nutrients depending upon the environment. By adding legumes in the cropping system, the

Treatments	Microbial population (per g soil)					Soil depth (cm)	
	Bacteria 10^5	Actinomycetes 10^4	Fungi 10^4	*Azotobacter* 10^2	PSB 10^2	0–15	15–30
Rice-fallow	42	0.3	0.1	22	0.4	192.1	156.5
Rice-MB (SR)	105	1.2	0.8	87	3.5	200.5	155.5
Rice-MB (SI)	167	5.5	1.3	202	6.0	244.0	195.7
C D (P = 0.05)	40.5	1.25	0.72	25.8	0.9	35.58	21.24

Table 3.
Soil microbial population as affected by legumes.

microbial population of useful microbes increased up to 3 to 4 times as compared to non-legumes additions. Additional soil biological parameters, improved after long term inclusion of legumes in the cropping sequence/cropping system.

8. Limiting factors for low production

In addition to low productivity, growing population, devastating climate change, complexities of diseases and pests, the socio-economic situation of pulse producers, poor storage facilities, etc. They increase the deficit of legumes that are available in the water.

1. **Area**: The growth of legumes is poor in marginal areas with low resource conditions is one of the main reasons for low pulse productivity. About 87% of the legume growing area in the country belongs to the rain cover system. The average rainfall of the main pulse producing states such as Madhya Pradesh (MP), Uttar Pradesh (UP), Gujarat and Maharastra is about 1000 mm and the variable coefficient of rainfall is 20–25%. Water stress is the most frequently cited reason for the poor harvest. Final drought and heat stress lead to forced maturity with low yields. The stress of drought can only reduce seed yield by 50% in the tropics. A leap in productivity can be achieved by applying life-saving irrigation, especially on Rabi legumes grown with remaining moisture. Two genes have been identified: "efl-1" and "ppd" for early flowering and maturation to escape the stress of drought (ICCV-2 in South India). The actual irrigated area under legumes remains stagnant at 13% of the total area. The availability of suitable soil moisture for plant growth depends on rainfall, water holding capacity, and soil depth in rainy areas. In southern India, soil water holding capacity usually limits grain yield to 50% compared to irrigation capacity. In contrast, in vertisol soil, the ability to retain water is larger, leading to a decrease in the growth rate of up to 5–20%. The increased amount of evaporation in southern India during the Rabi season leads to serious restrictions on the implementation of green beans during drought. Another major problem is soil salinity and alkalinity. High salinity and alkalinity in the semi-arid tropics and the Indo-Gangetic plains of the irrigated areas are of particular interest as most grain legumes are sensitive to salinity and alkalinity.

2. **Pests and diseases**: Among fusarium wilt diseases, associated with the root rot complex, perhaps the most common disease causes significant yield losses in mung beans (**Table 4**). *Fusarium wilt*, sterile mosaic as well as *Phytophthora blight*, yellow mosaic, *Cercospora* spp., and white rust on green and urban peas and rust also cause significant damage. 250 species of insects affect legumes in India. Of these, nearly a dozen cause significant damage to crops. On average, 2–2.4 million tons of legumes worth about 6000 rupees are lost each year due to damage from a pest combination.

3. **Problems with blue bulls**: Favored by blue bulls, the area of legumes is transferred to other crops. Legumes are vulnerable to attack by the blue bull in the Indo-Gangetic Plain. Due to the widespread threat, particularly in Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan and Chhattisgarh, farmers did not allow the possibility of in pulse production. There is no domestic feasible strategy to effectively combat the threat.

4. **Unfavorable climatic conditions**: Poor soil and agro-climatic conditions not only affect the legumes sowing time but also shorten the time of the growing

Crop	Insect-pest	Yield loss (%)	Disease	Yield loss (%)
Chickpea	*Fusarium* wilt and *Ascochyta* blight	50–100	Pod-borer and cutworm	10–90
Pigeonpea	Sterility mosaic virus	20–70	Pod-borer and leaf	70–80
Cowpea and mungbean	Yellow mosaic virus	10–100	Whitefly	20–25
	Rust, wilt and *Sclerotia blight*	20–70	Pod-borer	—
Field pea	Powdery mildew	10–30	Stem and pod-borer	—

Source: Das [44]; Pande et al. [45] and Satyagopal et al. [46, 47].

Table 4.
Yield loss in major pulses as caused by weeds, diseases, and insect-pests.

season, but also have to deal with cold damage at the start of the period of the vegetative segment, freezing all biological activity for a long time. The sudden rise in temperature not only causes forced maturity but also causes many biological stresses, diseases, and insect pests [48]. Traditionally, the cultivation of the Rabi legume has been delayed until the last week of November and, under extreme circumstances, until the first half of December, for obvious reasons. However, the optimal time for lentils planting is the first half of October. However, some winter legumes, including lentils, are also grown in pairs in eastern India, making it easy to grow even before the rice is harvested.

5. **Abnormal soil conditions**: In general, legumes prefer neutral soil reactions and are very sensitive to acid, salt, and alkaline conditions and most legumes have phosphorus deficiency. Therefore, P requires significant attention in legume production systems [49]. Indian soil, in particular, the soil in the northwest has a high pH unlike in the east and northeast, characterized by acid soils. Due to these soil conditions, micronutrient deficiency manifests itself in acute scarcity. An acute deficiency of zinc, iron, boron, molybdenum, and secondary nutrients such as sulfur, especially in legumes also reduce the productivity in terms of quality and quantity.

6. **Physiological constraints**: Legumes (plants C-3) have low yield potential and form a group of physically inefficient plants compared to cereals (C-4 plants) such as rice, sorghum, and corn [50].

Crop	Biotic stress	Abiotic stress
Chickpea	Weeds, *Fusarium* wilt, root rot, chickpea stunt, gray mold and pod-borer	Low temperature and nutrient stress
Pigeonpea	Weeds, *Fusarium* wilt, mosaic and pod-borer complex	Cold, terminal drought and waterlogging
Mungbean	Mosaic virus, root and stem rot, stem *Agromyza and* sucking insect-pests stress	Pre-harvest sprouting and temperature
Lentil	*Fusarium* wilt, root rot, and rust	Moisture and temperature

**[52].*

Table 5.
Important abiotic and biotic stresses limiting the production of major legumes crops in India.

7. **Legume marketing**: The legumes market is fragmented due to the dispersion of production and consumption in all states. Farmers/village traders sell their market surplus immediately after harvesting due to storage losses of pests, while some large traders/wholesalers trade between large markets and stock in legumes to make a profit from speculative profits during the off-season. For this reason, farmers did not take advantage of the higher market prices for pulse [51].

8. **Abiotic stress in terms of crops:** Abiotic stress is mainly inevitable and the most damaging factor for the growth and productivity of legume crops, especially in non-irrigated areas (**Table 5**). The capacity to effectively tolerating this type of stress by the adoption of suitable strategies based on research trails. Fixation, absorption, and assimilation of nitrogen by legumes are reduced due to a reduction in hemoglobin in the nodules and the number of nodules under water stress conditions [53].

9. Recent developments and legume production policies

9.1 Livestock project

Application of biotechnology tools to create a genetic modification for biotic and abiotic stresses and develop varieties suitable for early maturation for late planting situations to escape final water stress and used in some crop systems [54].

9.2 Planting techniques on high beds

Planting on a tall bed is an effective agronomic intervention, especially in areas with heavy rainy season legumes like pigeon peas, chickpeas, and beans. In pigeon peas, the method of planting strips and beds also reduced the incidence of *Phytophthora blight* [55]. Besides, better drainage under growing plantations also reduces the risk of root and stem rot [56]. It helps with controlled irrigation in beds and saves irrigation water (up to 30%) and expensive inputs such as seeds and fertilizers [57]. An increase in the productivity of legumes such as pigeon pea, urdbean, and chickpea was also observed due to the nodding and better growth of culture on a large bed [58].

9.3 Agricultural conservation (CA)

Crops such as summer mung beans can be a sequential partner of crop systems in April–June because legumes have a "preservative" effect on soil nitrogen (N) compared to non-bean crops and are beneficial for crops after crop. Pigeon-wheat and mung-bean systems have shown a clear advantage over wheat-wheat in conservation agriculture. No-tillage and retention of surface residues (tillage for soil conservation) improve the productivity of mung beans compared to conventional tillage practices [57]. Besides, legumes do not need to plow and retain crop residues that provide habitat for beneficial organisms by providing C substrate to heterotrophic microorganisms and increasing microbial activity and improve soil C and N [59].

9.4 Future outlook of organic grain legumes

The literature review presented here identifies that organic legume planting has great potential to promote soil sustainability and organic farming. Organic legumes' ability to improve soil properties (e.g. physical, chemical, and biological) makes them necessary to achieve sustainability goals. Given the immense promise of legumes as a soil amendment, the uncertainties described above must be handled objectively. There is an urgent need to understand the future needs and role of organic legumes in soil sustainability and food security and nutrition.

10. Conclusion

In the modern world, the demand for organic products is increased day by day in such products organic legume had also a great importance. In major organic farms, the adaptability of organic legumes is less as compared to other crops; even they had the capability to acts as a biological nitrogen fixer and act as green manure to other organic crops. There are a lot of abiotic and biotic factors that will adversely affect the productivity and yield of organic legumes. But these stress factors will be compressed by the adoption of suitable techniques on organic farms. This aside, proper market facilities, minimum support prices, and bridgeable gaps reduction and post-harvest management are important for adoption of organic farming in grain legumes and special subsidies in the form of monetary and non-monetary input along with crop insurance can help the farmers to adopt organic legume production without any hesitation.

Author details

Amanpreet Singh* and Harmandeep Singh Chahal
Department of Agriculture, Khalsa College Amritsar, Punjab

*Address all correspondence to: nandgharia@gmail.com

References

[1] Babu S, Singh R, Avasthe RK, Yadav GS. Strategies for enhancing the productivity of organic agriculture in the north eastern region of India. In: Souvenir and Conference Book of National Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences, held at Gwalior, Madhya Pradesh, India, 12-13 December 2015. pp. 55-58

[2] Avasthe RK, Singh R, Babu S. Organic legumes production in India: Perspectives and opportunities. Indian Journal of Agronomy. 2016;**61**(Special issue):93-101

[3] APEDA. Annual report of APEDA regarding legymes and pulses. 2019

[4] Pooniya V, Choudhary AK, Dass A, Bana RS, Rana KS, Rana DS, et al. Improved crop management practices for sustainable pulse production: An Indian perspective. Indian Journal of Agricultural Sciences. 2015;**85**(6):747-758

[5] Ali M. Consolidated Report on *Kharif* and *Rabi* Legumes, Agronomy 1997-1998, All India Pulse Improvement Project. Kanpur, Uttar Pradesh: Directorate of Legumes Research; 1998

[6] Yadav A, Suri VK, Kumar A, Choudhary AK, Meena AL. Enhancing plant water relations, quality, and productivity of pea (*Pisum sativum* L.) through AM fungi, inorganic phosphorus, and irrigation regimes in a Himalayan acid Alfisol. Communications in Soil Science and Plant Analysis. 2015;**46**(1):80-93

[7] Sharma DP, Singh MP, Gupta SK, Sharma NL. The response of pigeon pea to short term water stagnation in a moderately sodic soil under field conditions. Journal of the Indian Society of Soil Science. 2005;**53**(2):243-248

[8] Pooniya V, Choudhary AK, Sharma SN, Bana RS, Rana DS, Rana KS. Mungbean (*Vigna radiata*) residue recycling and varietal diversification for enhanced system productivity and profitability in basmati rice (*Oryza sativa*)–wheat (*Triticum aestivum*)–mungbean cropping system. In: Proceedings of National Symposium on Crop Diversification for Sustainable Livelihood and Environmental Security, held during 18-20 November 2014 at PAU, Ludhiana. 2014. pp. 629-630

[9] Padhi AK. Effect of sowing date and planting geometry on a yield of red gram (*Cajanus cajan*) genotypes. Indian Journal of Agronomy. 1995;**40**(1):72-76

[10] Kumar R, Singh M, Waldia RS. Opportunities for extension in area and production of spring/summer mungbean (Vigna radiata) in Haryana (India). Improving income and nutrition by incorporating mungbean in cereal fallows in the indo-Gangetic Plains of South Asia, DFID Mungbean project for 2002-2004. In: Proceedings of Final Workshop and Planning Meeting, Punjab, 27-31 May 2004. Ludhiana, Punjab, India: Agricultural University; 2006. pp. 236-245

[11] Gupta S, Bhowmick MK. Scope of growing Lathyrus and lentil in relay cropping systems after rice in West Bengal, India. Newsletter. 2005;**4**:28-33

[12] Shweta S, Malik M. Response of pulse production to phosphorus—A review. Agricultural Reviews. 2014;**35**(4):295-298

[13] Malhothra RS. Achievements and current status of BNF research in Asia-Pacific. In: International Workshop on Biological Nitrogen Fixation for Increased Crop Productivity, Enhanced Human Health, and Sustained Soil Fertility, 10-14 June. Montpellier, France: INSA-INRA; 2002

[14] Kumaravelu G, Kadambian D. Panchagavya and its effect on the

growth of the green gram cultivar K-851. International Journal of Plant Sciences. 2009;**4**(2):409-414

[15] Choudhary RG. Effect of mulching on Ascochyta blight of pea. In: Annual Report 1990-91. Umiam, Meghalaya: ICAR Research Complex for NEH Region; 1990. p. 43

[16] Meena RS, Yadav RS, Reager ML, De N, Meena VS, Verma JP, et al. Temperature use efficiency and yield of groundnut varieties in response to sowing dates and fertility levels in the Western dry zone of India. American Journal of Experimental Agriculture. 2015;**7**(3):170-177

[17] Lal R. Sequestering carbon in soils of agro-ecosystems. Food Policy. 2011;**36**:S33-S39

[18] Mitran T, Meena RS, Lal R, Layek J, Kumar S, Datta R. Role of soil phosphorus on legume production. In: Meena et al., editors. Legumes for Soil Health and Sustainable Management. India: Springer; 2018. DOI: 10.1007/978-981-13-0253-4_15

[19] Duchene O, Vian JF, Celette F. Intercropping with legume for agroecological cropping systems: Complementarity and facilitation processes and the importance of soil microorganisms; a review. Agriculture, Ecosystems and Environment. 2017;**240**:148-161

[20] Pivato B, Mazurier S, Lemanceau P, Siblot S, Berta G, Mougel C, et al. *Medicago* species affect the community composition of arbuscular mycorrhizal fungi associated with roots. The New Phytologist. 2007;**176**:197-210. DOI: 10.1111/j.1469-8137.2007.02151.x

[21] Gills MS, Prasad K, Ahalawat IPS. Improving the sustainability of rice-wheat cropping system through pulses: Weeds and imperatives. In: Ali M, Gupta S, Basu PS, Naimuddin, editors. Legumes for Ecological Sustainability. Kanpur: Indian Society of Pulses Research and Development; 2009. pp. 71-91

[22] Kureh I, Kamara AY. Effects of sole cropping, intercropping, and rotation with legume trap-crops on Striga control and maize grain yield in farmers' fields in the northern Guinea Savanna. In: Badu-Apraku B, MAB F, Lum AF, Menkir A, Ouedraogo M, editors. Demand-driven technologies for sustainable maize production in West and Central Africa. Fifth Biennial West and Central Africa regional maize workshop, 3-6 May 2005, IITABénin. 2005. pp. 169-179

[23] Lithourgidis AS, Dordas CA, Damalas CA, Vlachostergios DN. Annual intercrops: An alternative pathway for sustainable agriculture. Australian Journal of Crop Science. 2011;**5**:396-410

[24] Lopez CG, Mundt CC. Using mixing ability analysis from two way cultivar mixtures to predict the performance of cultivars in complex mixtures. Field Crops Research. 2000;**68**(2):121-132

[25] Yusuf AA, Iwuafor ENO, Olufajo OO, Abaidoo RC, Sanginga N. Effect of crop rotation and nitrogen fertilization on yield and nitrogen efficiency in maize in the northern Guinea Savanna of Nigeria. African Journal of Agricultural Research. 2009;**4**(10):913-921

[26] Nair KPP, Patel UK, Singh RP, Kaushik MK. Evaluation of legume intercropping in the conservation of fertilizer nitrogen in maize culture. Journal of Agricultural Science. 1979;**93**(1):189-194

[27] Kumar S, Sheoran S, Kumar SK, Kumar P, Meena RS. Drought: A challenge for Indian farmers in context to climate change and variability. International Journal of Scientific Progress & Research. 2016;**11**:6243-6246

[28] Inal A, Gunes A, Zhang F, Cacmak I. Peanut/maize inter-cropping induced changes in rhizosphere and nutrient concentrations in shoots. Plant Physiology and Biochemistry. 2007;**45**:350-356

[29] Fustec J, Lesuffleur F, Mahieu S, Cliquet JB. Nitrogen rhizodeposition of legumes: A review. Agronomy for Sustainable Development. 2010;**30**:57-66

[30] Ghaley BB, Hauggaard-Nielsen H, Hogh-Jensen H, Jensen ES. Intercropping of wheat and pea as influenced by nitrogen fertilization. Nutrient Cycling in Agroecosystems. 2005;**73**:201-212

[31] Barbosae S, Lima PI, Silva PS, de Oliveira OF, de Sousa RP. Planting times of cowpea intercropped with corn in the weed control. Revista Caatinga. 2008;**21**(1):113-119

[32] Raji JA. Intercropping soybean and maize in a derived savanna ecology. African Journal of Biotechnology. 2007;**6**(16):1885-1887

[33] Dinnes DL, Karlen DL, Jaynes DB, Kaspar TC, Hatfield JL, Colvin TS, et al. Nitrogen management strategies to reduce nitrate leaching in tile-drained Midwestern soils. Agronomy Journal. 2002;**94**:153-171

[34] Sofi PA, Baba ZA, Hamid B, Meena RS. Harnessing soil Rhizobacteria for improving drought resilience in legumes. In: Meena RS et al., editors. Legumes for Soil Health and Sustainable Management. Springer; 2018. DOI: 10.1007/978-981-13-0253-4_8

[35] Siddique KHM, Johansen C, Kumar Rao JVDK, Ali M. Legumes in sustainable cropping systems. In: Kharkwal MC, editor. Food Legumes for Nutritional Security and Sustainable Agriculture. Proceedings of the fourth international food legumes research conference (IFLRC-IV), October 18-22, 2005, New Delhi, India. Vol. 1. New Delhi: Indian Society of Genetics and Plant Breeding; 2008. pp. 787-819

[36] Knight TR, Dick RP. Differentiating microbial and stabilized β-glucosidase activity relative to soil quality. Soil Biology and Biochemistry. 2004;**36**:2089-2096

[37] Devare M, Londono RLM, Thies JE. Neither transgenic Bt maize (MON863) nor tefluthrin insecticide adversely affect soil microbial activity or biomass: A 3-year field analysis. Soil Biology and Biochemistry. 2007;**39**:2038-2047

[38] Leterme P, Carmenza Munoz L. Factors influencing legume consumption in Latin America. The British Journal of Nutrition. 2002;**88**(Suppl 3):251-254

[39] Chintala R, Mollinedo J, Schumacher TE, Malo DD, Julson JL. Effect of biochars on chemical properties of acidic soil. Archives of Agronomy and Soil Science. 2013;**60**:393-404

[40] Deakin WJ, Broughton WJ. Symbiotic use of pathogenic strategies: Rhizobial protein secretion systems. Applied Soil Ecology. 2009;**7**:312-320

[41] Prell J, Poole P. Metabolic changes of rhizobia in legume nodules. Trends in Biotechnology. 2006;**14**:161-168

[42] Liang B, Lehmann J, Sohi SP, Thies JE, O'Neill B, Trujillo L, et al. Black carbon affects the cycling of non-black carbon in the soil. Organic Geochemistry. 2010;**41**:206-213

[43] Tilak KVBR. Response of sesbania green manuring and mungbean residue incorporation on microbial activities for sustainability of a rice-wheat cropping system. Journal of Agriculture and Rural Development in the Tropics and Subtropics. 2004;**105**(2):189-196

[44] Das TK. Weed Science: Basics and Applications. Jain Brothers, New Delhi: India; 2008. pp. 666-679

[45] Pande S, Sharma M, Kumari S, Gaur PM, Chen W, et al. Integrated foliar diseases management of legumes. In: Proceedings of International Conference on Grain Legumes: Quality Improvement, Value Addition, and Trade, 14-16 February 2009. Kanpur, Uttar Pradesh, India: Indian Institute of Pulses Research; 2009. pp. 143-167

[46] Satyagopal K, Sushil SN, Jeyakumar P, Shankar G, Sharma OP, Boina, et al. AESA based IPM Package for Redgram. Rajendranagar, Hyderabad, India: National Institute of Plant Health Management; 2014a

[47] Satyagopal K, Sushil SN, Jeyakumar P, Shankar G, Sharma OP, et al. AESA Based IPM Package for Blackgram and Greengram. Rajendranagar, Hyderabad, India: National Institute of Plant Health Management; 2014b. p. 43

[48] Ali M, Gupta S. Carrying capacity of Indian agriculture: Pulse crops. Current Science. 2012;**102**(6):874-881

[49] Kumar A, Suri VK, Choudhary AK. Influence of inorganic phosphorus, VAM fungi, and irrigation regimes on crop productivity and phosphorus transformations in okra (*Abelmoschus esculentus L.)–pea (Pisum sativum L) cropping* system in an acid Alfisol. Communications in Soil Science and Plant Analysis. 2014;**45**(7):953-967

[50] Reddy AA. Legumes production technology: Status and way found. Review of Agriculture. 2009;**XLV1**(52):451

[51] Naryan, Kumar. Constraints of growth in area production and productivity of legumes in India: An analytical approach to major legumes. Indian Journal of Agricultural Research. 2015;**49**(2):114-124

[52] Reddy AA. Impact Assessment of Pulses Production Technology, Research Report No 3. Kanpur, Uttar Pradesh, India: Indian Institute of Pulses Research; 2006

[53] Krishnamurthy L, Kashiwagi J, Gaur PM, Upadhyaya HD, Vadez V. Sources of tolerance to terminal drought in the chickpea (*Cicer arietinum* L.) minicore germplasm. Field Crops Research. 2010;**119**(2-3):322-330

[54] Umesha C, Sridhara CJ, Kumarnaik AH, Shivarajkumar HS. Ways to bridge yield gaps and production problems in pigeonpea cropping systems. Journal of Pharmacognosy and Phytochemistry. 2017;**6**(5):2651-2657

[55] Chauhan VB, Singh VB, Singh ON. Integrated management on *Phytophthora* blight of pigeon pea. Legume Research - An International Journal. 2005;**18**(1):46-49

[56] Chaudhary RG, Naimuddin. Resource conservation technologies and integrated disease management strategies in legumes. In: Ghosh PK, Kumar N, Venkatesh MS, Hazra KK, Nadarajan N, editors. Resource Conservation Technology in Legumes. Jodhpur: Scientific Publisher; 2014. pp. 535-553

[57] Kumar N, Singh MK, Ghosh PK, Hazra KK, Venkatesh MS, Nadarajan N. Resource conservation technology in pulse-based cropping systems. In: Technical Bulletin. Kanpur: Indian Institute of Legumes Research; 2012. pp. 1-35

[58] Kumar N, Singh MK, Praharaj CS, Singh U, Singh SS. Performance of chickpea under different planting methods, seed rate, and irrigation level in indo-Gangetic Plains of

India. Journal of Food Legumes. 2015;**28**(1):40-44

[59] Bhattacharyya R, Das TK, Pramanik P, Ganeshan V, Saad AA, Sharma AR. Impacts of conservation agriculture on soil aggregation and aggregate-associated N under an irrigated agro-ecosystem of the Indo-Gangetic plains. Nutrient Cycling in Agroecosystems. 2013;**96**:185-202